Combining seismic interpretation, gravity inversion and forward modelling finds new structures in the Otway Basin.

GEOLOGICAL SURVEY OF VICTORIA

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Background

During studies on the western Otway Basin for the Victorian Gas Program in 2017-2020, existing well and seismic data was shown to be insufficient to constrain the structural relationships between the Tartwaup Fault (TFZ), the Portland Trough (PT), the Normanby Terrace (NT), the nearshore Bridgewater High (BH) and the Voluta Trough (VT). Figure 1 shows available seismic data across the onshore and nearshore.

The lack of constraint was thought to be due to a data gap across the nearshore and coastal zone where legacy seismic and well data are poor quality and sparse (figures 1a & 3). Previous interpretations postulated the presence of a fault at, or very near, the present day coast. An airborne gravity gradiometry survey was acquired over the Otway Basin in 2020, in part to fill this gap and test previous interpretations.

Inversion and forward modelling of the 2020 Otway Basin, airborne gravity and gradiometry survey (McLean et al. 2021) showed that previous interpretations had significantly underestimated the thickness of basin sediments within the Portland Trough. Additionally, the Bridgewater High was a larger, more continuous basement structure than had been previously interpreted. Our reinterpretation of the Portland Trough places its base beneath the depth of existing seismic coverage (figure 3) creating an additional gap in legacy data

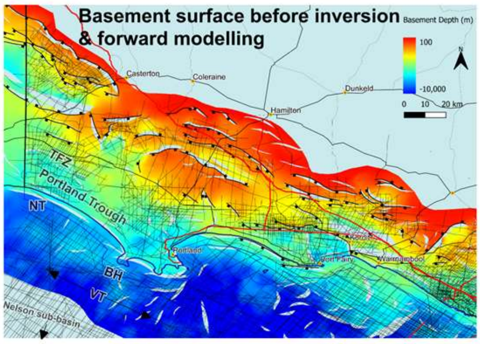

Figure 1a: Basement surface and 2D seismic extent (black lines) before inversion. (data from Romine et al. 2020)

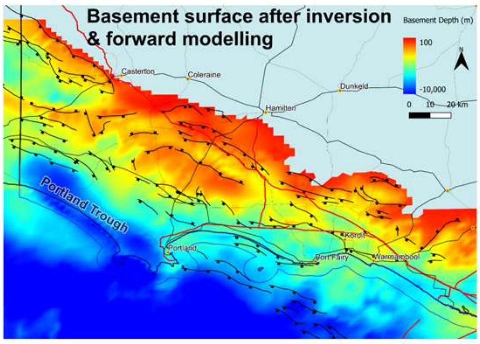

Figure 1b: Basement surface after inversion and forward modelling (data from McLean et al. 2021)

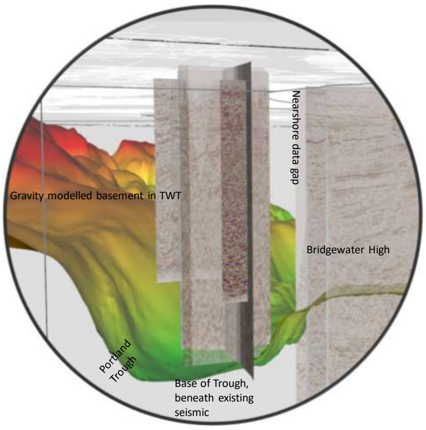

Figure 3: Seismic data gap in relation to the Portland Trough and Bridgewater high.

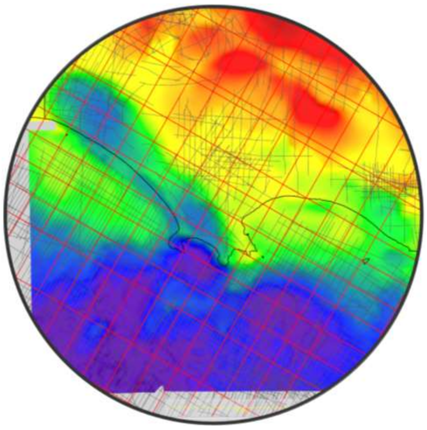

Figure 4: Psuedo section grid (red lines) constructed to infill data gaps with interpolation and interpretation between and beneath existing seismic datasets (grey lines). Grid spacing is 7.5km and 15km.

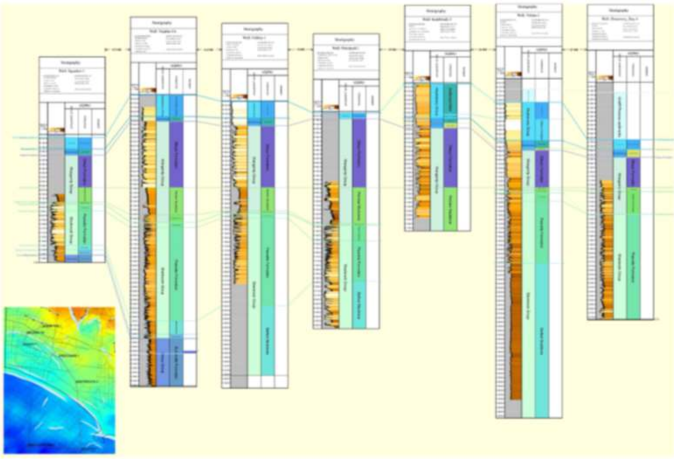

Figure 2: Well section across the Portland Trough, Paleogene-Neogene and Sherbrook Group thickening is apparent.

Interpretation & modelling

Existing interpreted seismic horizons and faults (Romine et al. 2020) were used where the data allowed high confidence. A basin-wide consistent set of formation tops (Eid et al. 2021) and newly digitized well logs contributed to constraining the Paleogene-Neogene and shallow sections of the Cretaceous and basement horizons (Figure 2). Paleozoic basement and Moho surfaces (McLean et al. 2021) were converted to TWT using a V0k depth of burial velocity model (Dunne & Boyd, 2021) and used to seed the interpretation of deeper structures in the data gaps and further offshore where no existing interpretation was available. The dotted brown line in Figure 6 represents the intersection of the inversion basement surface for that section.

A series of pseudo seismic lines were generated in Paradigm's SeisEarth software to allow interpretation at a regional scale and enable interpreted features to be extended across data gaps. The interpretations were informed by the seed interpretation and nearby 2D seismic lines.

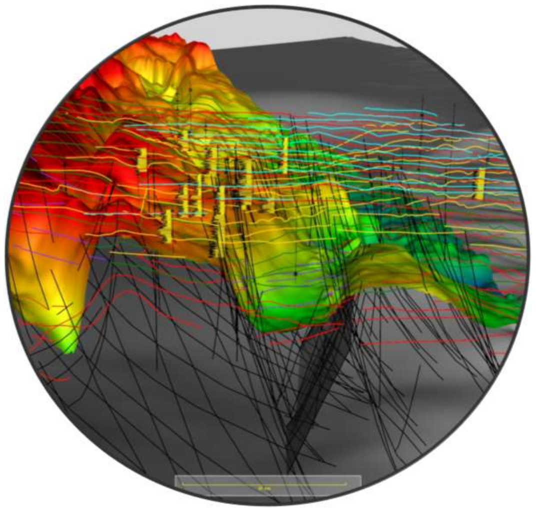

Figure 5: Interpreted horizons and faults on Psuedo seismic lines with Basement (red-green) and Moho (greyscale) surfaces.

Results

Figure 6 demonstrates the results of the study. Two faults have been interpreted and interpolated across the nearshore data gap to account for the visible and implied structures in this region. Faults are extrapolated to the modeled Moho surface, but we expect they would have propagated upwards from below that depth. The Bridgewater High (BH) is interpreted as a long-lived basement high that forms the southern boundary of a half-graben containing an undrilled sequence of Crayfish sub-group sediments at the base of the Portland Trough (PT). It appears analogous to the Penola Trough. The Normanby Terrace (NT) formed in the mid to late Cretaceous as a result of extension. It is a late Cretaceous, Sherbrook Group feature and sits between the Tartwaup Fault onshore and the series of domino faults across the continental shelf further offshore.

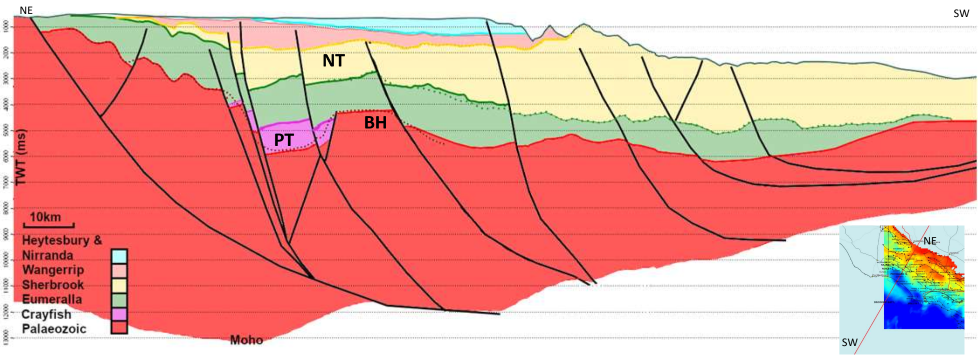

Figure 6: Results shown in section. Interpreted horizons and faults with modelled Moho and Basement (seed is dotted brown).

Discussion

While the "deep Portland Trough, Crayfish Sub-group" interpretation fits all of the available data, has a nearby analogue and fits regional tectonic and structural models, it is not a unique solution. The additional sedimentary section could have been generated during the deposition of the Eumeralla Formation or the Sherbrook Group. This would require structural complexity that isn't supported by currently available, sparse, data.

Localised lower density basement material (such as might occur due to the presence of large granite plutons) aligned beneath a shallower Portland Trough could equally explain the gravity data and match other available data.

Deeper, high quality seismic over the rift sequence to image the basement and structures within the Palaeozoic rocks would allow this model to be tested.

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